THE GREATER INCREASE IN SIZE AND INTENSITY OF THE EXTRATROPICAL CYCLONE BY NIGHT THAN BY DAY

W. J. HUMPHREYS

Mr. C. L. Mitchell, of the United States Weather Bureau, has called my attention to the interesting fact that winter cyclones moving northeastward in the United States, and doubtless similar storms also in other parts of the world, increase in size and intensity more rapidly by night than by day. Perhaps this phenomenon and its explanation are well known, but even so a repetition, if it be a repetition, of its brief explanation may be in order, for surely it is not very widely known.

In general, as everyone knows, the cool section of a cyclonic area is relatively clear and the warm section cloudy. At night, therefore, the clear section gets colder, or at least colder than it otherwise would be, owing to the great net loss of heat from the surface by radiation, while the clouded side more nearly maintains its temperature. During the daytime, on the other hand, the clear side warms up by insolation while the clouded portion again changes in temperature but little. That is, during the night the temperature contrast between the warm and the cool portions of the cyclone becomes or tends to become more and more pronounced and during the day less and less so. Furthermore, there is greater interference to the flow of the colder air during the daytime, owing to the thermal convection caused by insolation, than at night when there is no such convection. Hence, owing to the greater temperature contrast at night than during the day, and less obstruction to wind movement the cyclone normally grows, or tends to grow, more rapidly at night than during the day.

NOVEMBER FLOODS IN NEW ENGLAND AND EASTERN NEW YORK

By H. C. FRANKENFIELD

The New England and eastern New York floods.—On the morning of November 3, 1927, pressure was quite low over Virginia and the Carolinas, while an increasing high pressure area was off the southeast coast of Newfoundland. Twelve hours later the center of the storm was just off the coast of New Jersey, with sea-level pressure of 29.32 inches, while the high pressure area to the northeastward had also increased in magnitude. It happened that the pressure development and distribution during the night of November 2 had been ideal for the occurrence of heavy precipitation. This, however, did not become apparent until the morning of November 3, and by the evening of that date torrential rains had fallen over eastern New York and western New England.

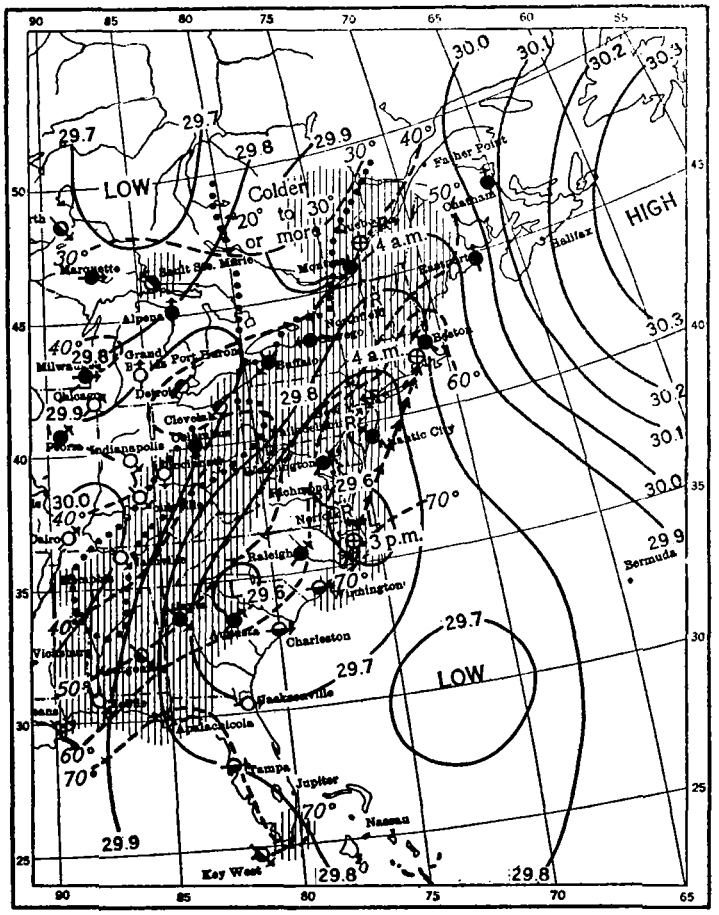

FIG. 1.—Weather conditions east of the Mississippi at 8 a. m. (eastern standard time) Two storm centers are shown on the 4th

The pressure distribution at 8 a. m., seventy-fifth meridian time on November 3, is shown in Figure 1. At that time a great barometric depression was centered over the Carolinas with local centers of relatively low pressure over the adjacent waters of the Atlantic and also north of the lower Lakes. By the next morning these several centers had consolidated, a northeastward movement had taken place with the result that there was now a single large depression of the barometer that stretched from the vicinity of Montreal to the Atlantic off the southern New England coast. Coincidently with this consolidation and movement, pressure in the oceanic HIGH off Newfoundland had risen to 30.50 inches, thus creating a pressure difference between St. Johns and Boston of 1.4 inches. In other words, an exceptionally strong pressure gradient for southeast to east surface winds over New England and the Hudson River Valley was formed. According to the well-known law of the turning of the wind with altitude southeast surface winds would turn to south winds, say from 1,500 to 3,000 meters; above that level they would have a large westerly component. These winds from off the sea were high in moisture content and heavy rains naturally resulted. Their long continuance was due to the fact that the relative position of the two barometric formations just described did not change materially for at least 36 hours.

The distribution of the precipitation for the period November 2–4 is graphically shown in Figure 2.

After the heavy rains of the day and night of November 3, a great flood was inevitable. So heavy was the rain, in fact, that the floods attained destructive proportions hours before the rains had ceased, and, most unfortunately, over much of the area covered they occurred during the night.

The great floods occurred in the Hudson Valley of New York, virtually all of Vermont and New Hampshire,

Massachusetts, and western Connecticut. There were also lesser floods in western Maine, eastern Connecticut, and Rhode Island. The flood was most severe in the Winooski Valley of Vermont, where the loss of life and property was so vast as to mark the disaster as the greatest in the history of the valley. Only of slightly less importance were the floods in the Connecticut Valley, the Lake Champlain drainage, and in the smaller streams in Massachusetts and Connecticut. One very remarkable feature was the rapidity of the rises in the rivers. There was no time for preparation except in the lower Connecticut Valley, and in many places no time for escape. Tragedy followed upon tragedy in such rapid succession that the people were left stunned and helpless for a time, and the losses of life and property were staggering for such a comparatively small area.

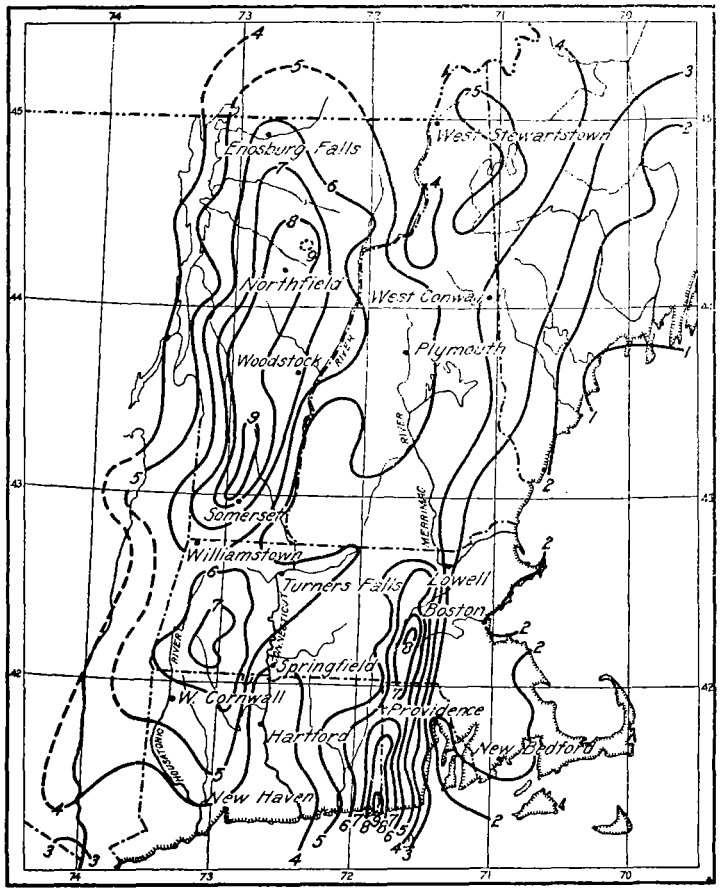

FIG. 2.—Distribution of rainfall Nov. 2-4, 1927, after a chart prepared for Mr. F. X. Goodnough, C. E., by Mr. George V. White. Copy received through the courtesy of Prof. Charles F. Brooks, Clark University.—*Editor*

Following are brief histories of the floods in the various districts. In the main they were extracted from reports made by Messrs F. E. Hartwell, Harry E. Adams, George W. Mindling, and G. S. Lindgren, meteorologists in charge of the Weather Bureau offices at Burlington, Vt., Hartford, Conn., Portland, Me., and Albany, N. Y., respectively:

Lake Champlain district—Winooski Valley.—The drainage basin of the Winooski River and its tributaries comprises about 1,000 square miles, and the length of the river proper is about 60 miles. About 90 per cent of the drainage basin is within the hills, mountains, and valleys where 8 or more inches of rain fell on November 3–4, and the discharge at the mouth of the river was possibly as much as 100,000 second-feet.[1]

[1] Engineering News Record, Nov. 10, 1927.

October precipitation was about 50 per cent in excess, so that when the November rains began the ground was well saturated and the brooks running full. The rainfall from November 2 to 4 broke all records for continuous rain in the State of Vermont, and all 24-hour records were also broken. At Burlington, Vt., the total rainfall for the period was 5.62 inches, with 4.49 inches in 24 hours. At Northfield, Vt., the total was 8.63 inches, with a 24-hour fall of 7.61 inches.

Records of river heights are scarce and there are very few comparative values. Montpelier, Vt., reported a high-water mark of about 16.5 feet against a previous mark of about 13.5 feet. As the surface of the main business street of the city is but 6 or 8 feet above the normal river level, there must have been from 8 to 10 feet of water over the entire business district. The known dead from the flood in the Winooski Valley numbered 48. Loss and damage reports are more or less incomplete, but it has been estimated that about one-half the losses in the State of Vermont occurred in the Winooski Valley. This would make the total for the valley about $12,000,000.

While river and flood service is not maintained in the Winooski Valley, a general flood warning sent out from Northfield was given as much distribution as possible, but the flood came so rapidly that little or nothing could be accomplished in the way of protection.

Another general warning of heavy rain on November 17 was followed by a second sharp rise, which carried out one or two temporary bridges and did other minor damage. Cold and snow checked the rising waters. Still another rise on December 1, following the heavy rain of November 30, flooded streets and many basements in Montpelier and carried away the United States Army pontoon bridge over the Winooski River at Burlington.

Space will not permit detailed description of the floods in different towns and cities, such as Burlington, Montpelier, Barre, Bolton, and Waterbury. The history of one would be the history of all.

Other Lake Champlain drainage.—Conditions were much the same over other drainages in the Lake Champlain district, differences lying mainly in diversity of details. Great damage was done in the valleys of the Missisquoi and Lamoille Rivers and Otter Creek, expecially the latter, in which is located the city of Rutland. There were 12 deaths reported, of which 4 occurred in Rutland, and the loss and damage were estimated at about $3,750,000.

Connecticut Valley.—The groundwork for these floods was laid in October. During this month there were rains of more than 1 inch over much of the valley and moderately heavy rains during the latter part of the month. These rains saturated the soil and made the streams very responsive to additional rains.

The average rainfall over the Connecticut Valley for the storm period of November 3–4 was 4.43 inches (9 stations), with maxima of 6.41 and 6.39 inches, respectively, at White River Junction and St. Johnsbury, Vt. Unofficial reports from other points in New Hampshire and Vermont indicated even heavier rains, as much as 15 inches in mountain sections. The central portion of the valley suffered most, especially the tributary sections, as the small streams were wholly unable to carry the flood waters, which rose to unprecedented heights.

At White River Junction, Vt., the Connecticut River rose from 6.4 feet at 8 a. m., November 3, to 35 feet 24 hours later. The stage of 35 feet is 5 feet higher than the former record of March 27, 1913. At Bellows Falls, Vt., there was a rise of 17.5 feet in 24 hours to an estimated

stage of 25.6 feet from 5 to 7 p. m., November 4, 6.6 feet above the previous record of March 28, 1913. At Holyoke, Mass., the crest of 14.8 feet at 6.30 p. m., November 5, was 2.1 feet above the previous record of October 5, 1869, while at Hartford, Conn., the crest of 29 feet at 11 p. m., November 6, was 0.8 foot below the previous record of May 1, 1854.

Sixteen lives were reported lost at various points throughout the main and tributary valleys. It would be useless to attempt to particularize as to the character of the loss and damage resulting from the flood. They were of the usual type of flood damage, but they were compressed within such comparatively narrow limits that they assumed tremendous proportions. While the losses in the valley were largely industrial, hundreds of families were rendered temporarily homeless. Many persons were trapped by the rapid rise of the waters, and the loss of life under the circumstances was indeed small. Accurate statistics of the loss and damage in the Connecticut Valley are not now available, but reasonable estimates place the total at about $18,000,000—$1,000,000 in Connecticut, $2,000,000 in Massachusetts, $6,000,000 in New Hampshire, and $9,000,000 in Vermont. Of these, probably all but about $2,000,000 were industrial losses.

The first warnings for the Connecticut River were issued at 9 a. m., November 4, when the first reports of the conditions in the upper valley were received. These warnings were of especial value in that portion of the valley from Northampton, Mass., southward, and the reported savings through them was $750,000. This amount would have been greatly exceeded had the warnings been more generally heeded. As it was, many persons could not be persuaded that the flood would reach the stages forecast, and they suffered accordingly.

Another heavy rain on November 17–18 called for advisory warnings of a second rapid rise, although flood stages were not actually reached as the rise was checked by low temperatures and snow.

Similar conditions in greater or less degree were experienced along all other rivers in southern New England, especially the West Branch, a western tributary of the Connecticut River. At Becket, Mass., on this river, Wheeler Dam gave way, submerging the town. Couriers in automobiles gave warning of the approach of the flood waters, and only one life was lost in Becket. The city of Westfield, Mass., also suffered severely, and four lives were lost. The Deerfield Valley of Massachusetts was probably saved from severe catastrophe by the storage behind the dams of the New England Power Co.

Merrimac Valley.—While the rainfall averaged more than 5 inches, flood conditions were not so severe in the Merrimac Valley, although in some localities considerable damage was done. There was no loss of human life reported. The Pemigewasset River, at Plymouth, N. H., reached a stage of 28 feet, while the Merrimac reached 14.7 feet at New Hampshire Power Co., Franklin Junction, N. H. (5.3 feet below the flood stage) on November 5; 12.2 feet at Concord, N. H. (2.2 feet above the flood stage) on November 5; and 11.2 feet at Manchester, N. H. (3.2 feet above the flood stage) on November 5. It was possible to issue some warning for the Merrimac flood early in the morning of November 4.

Androscoggin River.—While the precipitation was somewhat less than to the westward, it was sufficient to cause a severe flood in the Androscoggin River. In the Rangeley Lake district it was the highest known flood, and between Gorham, N. H., and the Maine boundary it was from 3 to 4 feet above any previous record. At Rumford, Me., the crest was 0.3 foot lower than in 1895. Lowlands along the river and its tributaries were extensively flooded from Gorham, N. H., to near Lewiston, Me. There was very little overflow below Lewiston.

One life was lost in New Hampshire. Reported loss and damage, excluding railroad data, were between $350,000 and $400,000, of which about $300,000 occurred in New Hampshire, mostly at Berlin and Gorham, N. H., and vicinity. Railway traffic was suspended for from one to three weeks, and highway traffic through Pinkham Notch, White Mountains, will probably be suspended until the spring of 1928.

Outside the Androscoggin system, overflow in the State of Maine was comparatively small. The stages of water were not unusual except for the time of the year. The Kennebec River at Waterville reached 9.1 feet, nearly 2 feet below the flood stage, while the discharge of the Penobscot River at Bangor was only 65,000 second-feet, whereas in 1923 it was 150,000 second-feet. Loss and damage were very small, only about $30,000. Two lives were reported lost.

Hudson Valley.—With respect to rapidity of rise and run-off, the Hudson floods were also the most remarkable of record. While the precipitation was quite heavy over the Mohawk and upper Hudson Valleys, the greater part of the water came from the eastern tributaries, the Hoosic, Battenkill Creek, and others, most of which have their sources in Vermont and northern Massachusetts. Some measurements reported by the United States Geological Survey are as follows: Battenkill Creek, at Battenville, N. Y., gauge height 17.7 feet, discharge about 20,000 second-feet, run-off per square mile 50.7 second-feet; Hoosic River, near Eagle Bridge, N. Y., gauge height 18.8 feet, discharge about 29,700 second-feet, run-off per square mile 58 second-feet; Poestenkill Creek, near Troy, N. Y., gauge height 8.4 feet, discharge 7,150 second-feet, run-off per square mile 81.3 second-feet. These figures are unprecedented and far above any previous record.

The Hudson River was not in flood much above Troy, N. Y. At this place the river rose from 1.6 feet at 8 a. m., November 3, to 21.7 feet, or 6.7 feet above the flood stage, about midnight of November 4–5. At Albany there was a rise from 2.4 feet on November 3 to 16.9 feet, or 4.9 feet above the flood stage, at 12.45 a. m., November 5.

Warnings for the flood were accurate and timely, and large quantities of goods were removed to places of safety. People feared a repetition of the flood of 1913, but the failure of the upper river and the Mohawk prevented this. No lives were lost. Property loss and damage, as reported, amounted to $2,027,700, most of which occurred in Columbia and Washington Counties.

LOSS AND DAMAGE

According to the best information obtainable, there were 88 human lives lost during the floods. Grouped according to States they were as follows:

Maine	2	Massachusetts	12
New Hampshire	2	Rhode Island	1
Vermont	63	Connecticut	8

Of the total of 63 deaths in Vermont, 48 were in the Winooski Valley, Waterbury alone contributing 21.

Considering the comparatively small areas involved, the property losses were staggering. Inability to properly estimate the intangible and potential losses militates against accurate statements, but from reports gathered from all available sources, it appears that the total of

loss and damage was about $32,600,000. Grouped by States the losses were approximately as follows:

Maine	$100,000
New Hampshire	6,400,000
Vermont	[1] 16,500,000
Massachusetts	6,000,000
Connecticut	1,000,000
New York	2,027,700
Total	32,027,700

No figures were obtained regarding the State of Rhode Island, but the amount must have been relatively small.

In the State of Vermont alone 930 bridges were either destroyed or severely damaged, and the total losses in roads and bridges, as reported by the State highway department, was $7,475,208. Industrial and agricultural losses were about $7,000,000 and $1,500,000, respectively. Houses totally destroyed numbered 264, and 1,339 more were badly damaged. Nine thousand two hundred and five persons were compelled to leave their homes. Fifteen hundred cows and some other livestock were lost. Statistics regarding other New England States were in less detail, but of the same character. The number of people rendered temporarily homeless was reported by the American Red Cross as 16,272.

Apparently railroad losses have not been included in the above summaries. These were very heavy, especially those of the Central Vermont Railway between Burlington and White River Junction, Vt. No attempt was made to secure detailed statements, but rough estimates gathered from the press and other sources aggregated about $5,000,000, irrespective of losses through enforced suspension of business, making a grand total of loss and damage of $37,577,700.

[1] A report to the Governor of Vermont by the Vermont flood survey committee gives the losses in the State, including railroad, telegraph and telephone lines, and street railways as $24,743,755, as reported up to Dec. 5, 1927.

THE VIRGINIA-DISTRICT OF COLUMBIA-MARYLAND TORNADO OF NOVEMBER 17, 1927

[Abstract of report by WILLIS E. HURD]

During Thursday, November 17, 1927, a LOW from the south, central over southwestern Virginia by the morning weather observations of that date, moved north-northeastward, the center passing some 50 miles west of the District of Columbia near midday.

About 2:15 p. m. a tornado formed in rough country in Fairfax County, Va., reaching the ground about 3 miles southwest of Alexandria. It traversed the western part of the city and the extreme southeast corner of Arlington County, then crossed the Potomac River at an acute angle. In the District of Columbia the naval air station and navy yard were visited, and from the latter (about Eighth and M Streets SE.) for about 2 miles to Benning Road and Nineteenth Street NE. the tornado swept a strip in a thickly built area. Beyond there was practically undeveloped land. The tornado went on in to Prince Georges County, Md., to near East Riverdale.

The length of path, well authenticated, is 17 miles. The width was found from 20 yards or less to not quite 300 yards, but seemingly averaged about 140 yards. The best established times were 2:34 p. m. at the naval air station and 2:38 at Benning Road, the latter noted by a trolley-car conductor. These are in good accord, but separated by too short a distance to fix the speed of advance satisfactorily.

The tornado was probably most intense in Alexandria and in Arlington County. It seemed to be rather intense, again just before and just after crossing the District-Maryland line. There was no fatality really due to the tornado, but those injured enough to require more than first-aid treatment numbered 31—10 in Alexandria, 2 in Arlington County, and 19 in Washington.

The total damage to property, according to conservative estimates, amounted to $690,000, distributed as follows: Alexandria, $200,000; Arlington County, $125,000; naval air station, $100,000; navy yard, $80,000; remainder of District of Columbia, $120,000; near-by communities in Maryland, $65,000. In Fairfax County the damage was so slight as not to be considered.

The advance of the tornado, when the path is accurately plotted on a large-scale United States Geological Survey map, is found to have been in direction north 33° east. The primary LOW during this 12-hour period between observations advanced about north 38° east, according to the Washington weather map. On April 5, 1923, the tornado that occurred a few miles northwest of the recent track advanced about north 59° east, while the primary LOW is indicated by the REVIEW Chart II as advancing during the 12 hours north 49° east.

This is the third tornado noted in the District of Columbia within a five-year period and very much the most serious. Also it is noteworthy that the Virginia portion of the track shows far greater damage than any one tornado ever before caused in that State.

It is of interest that the observatory of the naval air station obtained an actual meteorological record of the tornado at close quarters, since it was struck by the right-hand edge of the funnel just prior to the destruction done to hangar, planes, and buildings. In advance of the tornado the reading of the barometer was 29.57 inches, which is only a hundredth of an inch lower than the simultaneous reading at the central office of the Weather Bureau, almost 4 miles to northwestward. The first violent blast at 2:34 p. m. gave a velocity of 93 miles from the south and south-southeast on the observatory register, with pressure suddenly dropping to 29.11 inches. The wind then shifted rapidly to southeast, east-southeast, and east, by which time the wind speed had dropped to 33 miles, with recovering pressure. At the Weather Bureau (distant about 3 miles) the wind at the time was from the southwest, velocity 16 miles, both wind and pressure being unaffected as far as the records indicate

WATERSPOUT IN THE POTOMAC RIVER, WASHINGTON, D, C., NOVEMBER 17, 1927

By WILLIS E. HURD

Nearly an hour and a half after the tornado of November 17, 1927, struck the eastern shore of the Potomac or, precisely, at 3:54 p. m., at which time the worst rain and wind squall of the general cyclone occurred at Washington, D. C., a waterspout formed in the river west of Anacostia. Although the spout was considerably veiled by the gloom and heavy rain then prevailing, it was seen from the naval air station to move directly toward the southeast and dash itself in pieces on the shore two minutes later. It is said to have been some 300 feet in height, reaching to the squall cloud, with river water seen to course up about one-third of its length. At this time the maximum wind velocity of 60 miles an hour for a two-minute period from the southwest was registered at the Weather Bureau. The wind direction for the hour preceding 3:45 p. m. had been from the south. This is probably the first waterspout known to have occurred along this portion of the Potomac.